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DEPARTMENTS.

SOLUTIONS OF PROBLEMS.

ARITHMETIC.

90. **Proposed by B. F. FINKEL, A. M., M. Sc., Professor of Mathematics and Physics, Drury College, Springfield, Mo.**

Find the greatest number of inch balls that can be placed in a box 10 inches square and 5 inches deep.

Solution by MARTIN SPINX, Wilmington, Ohio, and the PROPOSER.

Using as a base a side of the box, we can place on this base, by square arrangement 50 balls. But by placing 5 balls in the first row, 4 in the second, and 5 in the third, and so on, we can place 50 balls in the first layer, there being 6 rows of 5 balls, and 5 rows of 4 balls. These eleven rows will leave .339 inches between the eleventh row and the end of the box. By placing the second layer of balls in the trihedral spaces of the first layer, the two layers will occupy a space 1 inch$+\sqrt{\{1^2-[\frac{2}{3}(\frac{1}{2}\sqrt{3})]^2\}}$ inches,$=1.8165$ inches, high.

Since the centers of the first row in the second layer are .289 inches in advance of the centers of the first row in the first layer, it follows that eleven rows can be put in the second layer, there being .339 inches$-$.289 inches, or .05 inches more room than is needed. But the second layer contains 49 balls,—the six odd rows containing 4 each and the five even rows 5 each. In this we can place in the box twelve layers,—50 balls in each of the odd numbered layers, and 49 in each of the even numbered layers. This makes a total of 594 balls.

Also solved, with different results, by *G. B. M. ZERR*, *CHAS. C. CROSS*, and *FREMONT CRANE*.

90. **Proposed by F. M. PRIEST, Mona House, St. Louis, Mo.**

A owes $6000 which is drawing 6% interest. He wishes to pay off the debt in six equal annual payments, the first to be due in one year. The whole portion of the claim unpaid at the end of each year to be accounted as principal, and to draw interest to the time of the next payment. Required the amount of each payment, so the six annual payments will discharge the obligation, interest and all.

I. **Proposed by P. S. BERG, Superintendent of Schools, Larimore, N. D.; J. A. MOORE, Professor of Mathematics, Millsaps College, Millsaps, Miss.; M. E. GRABER, Mt. Eaton, O.; MARTIN SPINX, Wilmington, O., M. A. GRUBER, A. M., War Department, Washington, D. C.**

Let x=annual payment.

Put a=debt, r=rate of interest, and n=number of annual payments.

We then have the general formula,

$$\frac{(100+r)\left\{\begin{array}{c}\dfrac{\ldots\ldots(100+r)\left(\dfrac{(100+r)a}{100}-x\right)}{100}-x\\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\\ \text{to } n\text{th payment}\end{array}\right\}}{100}-x=0,$$

which reduces to

$$a(100+r)^n=x[100(100+r)^{n-1}+100^2(100+r)^{n-2}+\ \ldots\ +100^{n-1}(100+r)+100^n].$$

Now, substituting 6 for r, 6 for n, and 6000 for a, we obtain

$$6000\times 1.06^6=x(1.06^5+1.06^4+1.06^3+1.06^2+1.06+1).$$

$\therefore\ x=8511.114673536\div 6.9753185376=1220.1757+.$

II. Solution by F. R. HONEY, Ph. B., New Haven, Conn.

Let x=amount of each annual payment.

$\therefore\ 6000+.06\times 6000-x=6360-x$=amount left after first payment.

And $6360-x+.06(6360-x)-x=6741.6-2.06x$=amount left after second payment.

Similarly, $7146.096-3.1836x$=amount left after third payment.

Similarly, $7574.86176-4.374616x$=amount left after fourth payment.

Similarly, $8029.3534656-5.63709296x$=amount left after fifth payment.

Similarly, $8511.114673536-6.9753185376x$=amount after sixth payment.

Then $8511.114673536-6.9753185376x=0$.

$\therefore\ 6.9753185376x=8511.114673536$.

$\therefore\ x=\$1220.176$=annual payment.

III. Solution by G. B. M. ZERR, A. M., Ph. D., President and Professor of Mathematics, The Russell College, Lebanon, Va.; W. H. DRANE, A. M., Professor of Mathematics, Jefferson Military College, Washington, Miss.

The portions of the principal paid each year are as

$1,\ 1/1.06,\ 1/(1.06)^2,\ 1/(1.06)^3,\ 1/(1.06)^4,\ 1/(1.06)^5$; or as $(1.06)^5, (1.06)^4, (1.06)^3, (1.06)^2, 1.06, 1$; or as 1.338226, 1.262477, 1.191016, 1.1236, 1.06, 1.

$1.338226+1.262477+1.191016+1.1236+1.06+1=6.976319.$

$(1/6.975319)\times\$6000=\$860.1757.$

$\$860.1756+\$6000\times .06=\$860.1758+\$360=\$1220.1757$, first payment.

$\$6000-\$860.1757=\$5139.8243$, amount still unpaid.

$(1.06/6.975319)\times\$6000=\$911.7862.$

$\$911.7862+\$5139.8243\times .06=\$911.7862+\$308.3895=\$1220.1757$, second payment.

$\$5139.8243-\$911.7862=\$4228.0381$, amount still unpaid.

$[(1.06)^2/6.975319]\times\$6000=\$966.4934.$

$\$966.4934+\$4228.0381\times.06=\$966.4934+\$253.6823=\$1220.1757$, third payment.

$\$4228.0381-\$966.4934=\$3261.5447$, amount still unpaid.

$[(1.06)^3/6.975319]\times\$6000=\$1024.4830$.

$\$1024.4830+\$3261.5447\times.06=\$1024.4830+\$195.6927=\$1220.1757$, 4th payment.

$\$3261.5447-\$1024.4830=\$2237.0617$, amount still unpaid.

$[(1.06)^4/6.975319]\times\$6000=\$1085.9520$.

$\$1085.9520+\$2237.0617\times.06=\$1085.9520+\$134.2237=\$1220.1757$, fifth payment.

$\$2237.0617-\$1085.9520=\$1151.1097$, amount still unpaid.

$[(1.06)^5/6.975319]\times\$6000=\$1151.1091$.

$\$1151.1091+\$1151.1097\times.06=\$1151.1091+\$69.0666=\$1220.1757$, sixth payment.

$\$1151.1097-\$1151.1091=\$0.0006$, unpaid still.

The above is all the work necessary for determining each equal payment, and at the same time working out the problem in full.

A short method by algebra is, $p=\dfrac{6000\times.06(1.06)^6}{(1.06)^6-1}=\$1220.176$.

91. Proposed by J. A. CALDERHEAD, M. Sc., Professor of Mathematics in Curry University, Pittsburg, Pa.

$1000.00. Cleveland, Ohio, May 26, 1893.

Two years after date I promise to pay John Davis, or order, one thousand dollars, for value received, interest six per cent. payable annually. J. M. LEWIS.

Indorsements: December 14, 1895, $560.56; May 11, 1896, $10.02; June 14, 1897, $545.06.

Find, by the United States' Rule, the amount due August 2, 1897.

Solution by G. B. M. ZERR, A. M., Ph. D., President and Professor of Mathematics, The Russell College, Lebanon, Va.; WALTER HUGH DRANE, A. M., Jefferson Military College, Washington, Miss.; and MARTIN SPINX, Wilmington, Ohio.

Principal, ...		$1000.00
Interest to December 14, 1895, 2 years, 6 months, 18 days, .		153.00
Amount, ...		$1153.00
First payment December 14, 1895, ...		560.56
New principal, ...		$ 592.44
Interest to June 14, 1897, 1 year, 6 months, . . .		53.3196
Amount, ...		$ 645.7596
Second payment, May 11, 1896, ...	10.02	
Third payment, June 14, 1897, . . .	545.06	555.08
New principal, ...		$ 90.6796
Interest to August 1, 1897, 1 month, 18 days, . . .		.7254
Amount or balance due, ...		$91.4050

Daniel G. Dorrance gets as a result $100.80. He computed interest on the annual payments. Mr. Drane, in a second solution does the same, but he gets a result of $100.138.